Biolife AN INTERNATIONAL QUARTERLY JOURNAL OF BIOLOGY & LIFE SCIENCES 4(3):547-569

ISSN (online): 2320-4257
www.biolifejournals.com

BIOLIFE RESEARCH ARTICLE

Timing of repeated head computerised tomography and its impact on the management of patients with moderate and severe traumatic brain injury (TBIS)

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ABSTRACT

The purpose of this prospective study over 100 patients who were admitted to surgical emergency unit was to define the indications, the timing and the frequency of repeated head computerized tomography (CT) scan in patients with moderate and severe traumatic brain injuries (TBIs) and to verify its impact on the management of those patients. we found that Performing an initial early CT brain within 2 hours interval from onset of trauma had a significance in comparison to 4 hours and 6 hours interval, none of the follow up CTs done upon improvement of GCS show any changes, more than half of patients who show new changes or progression of lesions in their follow up CT did it due to deteriorated GCS, the follow up CT done routinely showed progression or new changes in around 70 % of the patients and affected the management in 60% of patients, the majority of the follow up CT at which medical management was done (n=40) was arranged at 12 hours interval from the initial CT done (30%) followed by those arranged at 6 hours (25%) and at 4 hours (22%), while follow up CT at which surgical intervention was done (n=21) was those arranged at 4 hours interval from the initial CT done (28%) followed by those arranged at 12 hours (24%) and 24 hours (24%).

Keywords: Computerised tomography, TBIS, GCS, trauma, patients.

INTRODUCTION

TBI is a major public health problem, the leading causes of head injury in the civilian population are road traffic accidents and falls. (Jager et al. , 2000).

Computed tomography (CT) has become the diagnostic modality of choice for head trauma due to its accuracy, reliability, safety, and wide availability. (Aaron G.Filler., 2010).

There is a consensus that patients identified as moderate risk or high-risk for intracranial injury should undergo early non-contrast CT for evidence of. There is a direct relationship between declining clinical or neurologic status as described by the GCS (Kido et al., 1992) and the incidence and severity of CT abnormalities related to head injury. (Reinus el al., 1996).

Early and repeated CT scanning may be required for deterioration, especially in the first 72 hours after head injury, to detect delayed hematoma, hypoxic-ischemic lesions, or cerebral edema. (Stein et al., 1993).

Follow up CT brain

Repeat CT scan is obtained to assess for the progression of injury with the expectation that a radiographic change alone might lead to a medical or surgical intervention. Several authors have questioned this practice in recent year (Sifri et al., 2004) and have recommended relying on clinical examination to analyze the need for a repeat head CT. (Lee at al., 1997).

More than 50%of patients with severe head injuries have progression of findings on CT scan that otherwise would go undetected due to their poor initial clinical status (Smith et al., 2007).

How to Site This Article:
Sara Mohamed Fouad, Ahmed Gaber Marei and Ahmed Abd el aziz (2016). Timing of repeated head computerised tomography and its impact on the management of patients with moderate and severe traumatic brain injury (TBIS). *Biolife*. 4(3), pp 547-569.

DOI: 10.5281/zenodo.7334054
Received: 8 July 2016;
Accepted; 26 August 2016;
Available online : 7 September 2016

Timing of follow up CT brain

Factors that will influence the timing of a routine repeat head CT are variable. First of all, clinical judgment should play a prominent role. (Lee et al., 1997). Other factors that should influence timing of routine repeat head CT are risk factors for injury progression on CT scan as coagulopathy, old age, raised ICP, multiple lesions in initial CT, ultra-early CT and low GCS. (Wang et al., 2006).

Impact of repeat CT scan in management decisions:

The alteration in management/ decision, based upon repeat CT scan, may not always be surgical. Expansion of or development of a new lesion, may warrant addition of dehydrating measures to reduce intracranial pressure, shifting to an intensive care unit or alteration of ventilator settings.(Ramesh et al.,2012).

Waiting to institute these measures till there is a clinical worsening may be detrimental at least in some patients. This can be avoided to some extent by a protocol of routine CT. (Figg et al., 2003).

Most evolutionary changes in the lesions occurred in the first 48 h, and in a small percentage of patients, even after that. It would be reasonable to have repeat CT scans in all patients up to this time period and be selective at a later time period. (Wang et al., 2006).

To sum up there is no clear guidelines for repeated CT brain, its timing or its impact on management of head injury. (Brown et al., 2007).

Aim of the Work:

The aim of the present study is to define the indications, the timing and the frequency of repeated head computerized tomography (CT) scan in patients with moderate and severe traumatic brain injuries (TBIs) and to verify its impact on the management of those patients.

Materials and Methods

Patients:

The study will include 100 patients with moderate and severe traumatic brain injuries who will be admitted to the department of emergency medicine at the Alexandria Main University Hospital.

Inclusion criteria:

1. Patients with moderate and severe traumatic brain injuries (TBIS).
2. Patients who were not previously operated based on the findings of The first head CT scan.
3. Hospitalized patients following the first head CT scan.

Exclusion criteria:

1. Patients with mild traumatic brain injuries (TBIS).
2. Patients who were previously operated after the first CT scan.
3. Non hospitalized Patients following the first head CT scan.

Methods

Study design:

A Prospective study will be conducted to collect data from one hundred patients with moderate to severe traumatic brain injuries who will be admitted to the department of emergency medicine in Alexandria Main university hospital at the year 2015.

Tools of data collection:

1-History taking:

- Detailed history of head trauma (type and time of injury, time interval between trauma and initial CT Brain).
- Age.
- History of medical diseases.
- Drug history including recreational drugs.

2-Clinical examination:

A. Primary survey including:
   - Airway
   - Breathing
   - Circulation
   - Disability: Glasgow coma scale GCS [16], check pupils and RBS
   - Thorough examination to detect other injuries

B. secondary survey:
   - Full clinical examination of all body
   - Glasgow coma scale(GCS)[16] on admission after primary respiratory and hemodynamic stabilization (Table-1)

Table-1: Glasgow Coma Scale (GCS) [16]

Eye opening	4 points
Eyes open spontaneously	4
Eyes open to verbal command	3
Eyes open to pain	2
No eye opening	1
Motor response	**6 points**
Obey commands	6
Localizing to pain	5
Withdrawal to pain	4
Flexion to pain	3
Extension to pain	2
No motor response	1
Verbal response	**5 points**
Oriented	5
Confused	4
Inappropriate words	3
Incomprehensive sounds	2
No verbal response	1

Score 13-15=Mild TBI
Score 9-12=Moderate TBI
Score 3-8=Severe TBI

3. Laboratory investigations:

A. Complete blood picture.
B. Serum urea and creatinine.
C. Serum sodium and potassium.
D. Coagulation Profile: PT, PTT, INR

4. Radiological study:

Multi slice CT brain.

The first CT scan of the brain was referred to as the admission CT (CT-1) and the time lapse between admission & the scan was recorded and the subsequent CT scans were numerically labeled as serial CTs (CT-2, CT-3…). The first CT scan (CT1) was done as soon as possible after hospital admission, the intervals between CTs was recorded, the indication of follow up CT either done routinely or upon GCs deterioration was recorded, the number of CTs done for each patient was recorded, the timing and the sequence of the follow up CT which impacted management medically or surgically was recorded.

5. Management:

The management will include:

a. *Observation:*
Observation and monitoring of clinical status, GCS and neurotropic medications.
b. *Medical management:*
Management of raised intracranial pressure by dehydrating measures (e.g mannitol, hypertonic saline, diuretics, head elevation) and hyperventilation.
c. *Surgery:*
According to the radiological findings (e.g. craniotomy for evacuation of intracranial hematoma, de-compressive craniotomy, ventricular drainage).

6. Outcome:

The outcome of patients with moderate and severe traumatic brain injuries (TBIS) will be assessed both radio logically by findings in follow up CT scan either the same ,resolving lesions, new findings or increase in the size of the initial lesions and clinically by impact on management either operated , received dehydrating measures or observed after undergoing follow up CT.

7-Ethical consideration:

Informed written consents will be obtained from the relatives of all patients included in the study.

RESULTS

This is a prospective study of one hundred (100) patients presenting with moderate and severe traumatic brain injury attending to surgical ED at Alexandria Main University Hospital who undergo follow up computerized tomographic scans.

1. Distribution of patients according to age &sex:

One hundred patients were included in this study, 82 patients were males and 18 patients were females. The age ranged from1.5 to 84 where 81 patients were more than 18 years and 19 patients were less than 18 years.

Table-2. Distribution of the studied cases according to demographic data (n = 100).

	No.	%
Age		
>18	81	81.0
<18	19	19.0
Min. – Max.	1.50 – 84.0	
Mean ± SD.	31.69 ± 18.84	
Median	26.0	
Sex		
Male	82	82.0
Female	18	18.0

Figure-1.Distribution of the studied cases according to Age

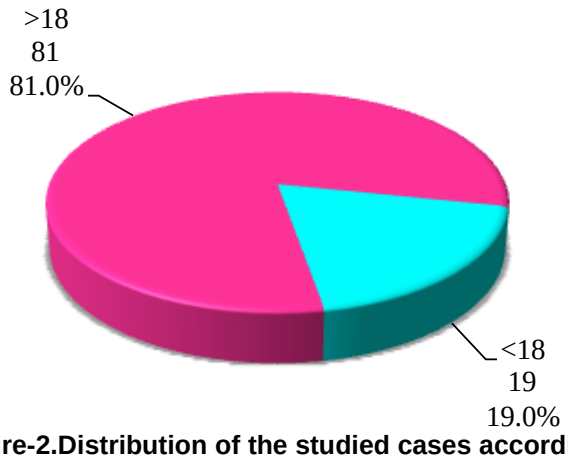
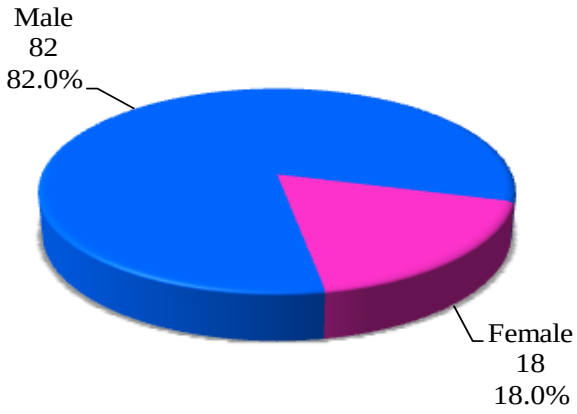


Figure-2.Distribution of the studied cases according to Sex



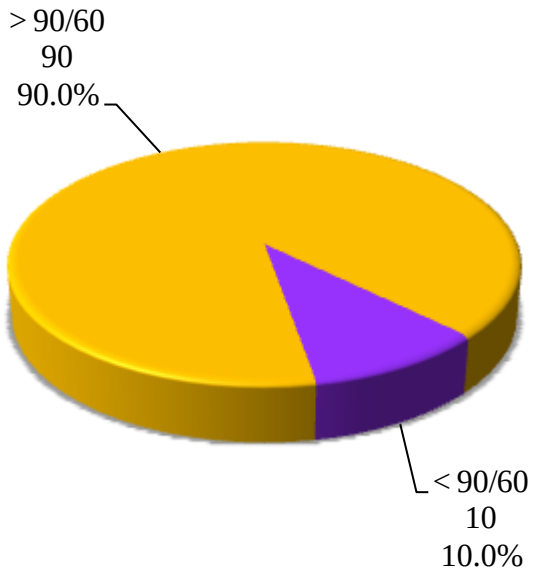
2. Distribution of patients according to blood pressure:

As regards blood pressure at admission, patients were classified to 2 groups those with blood pressure more than 90/60 which represent the majority of patients (90%) and those with blood pressure less than 90/60 which represent (10%).

Table-3. Distribution of the studied cases according to blood pressure (n = 100)

	No.	%
Blood pressure		
> 90/60	90	90.0
< 90/60	10	10.0

Figure-3. Distribution of the studied cases according to blood pressure



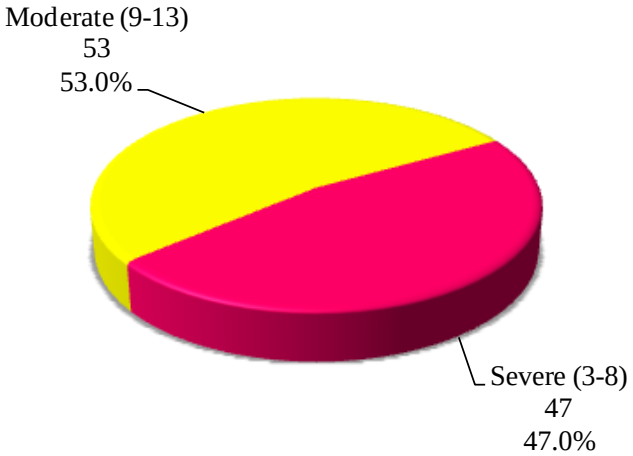
3. Distribution of patients according to GCS on admission:

According to GCS on admission ,among the one hundred studied patients, 47 patients had severe traumatic brain injury with GCS equal to or less than 8 while 53 patients had moderate traumatic brain injury with GCS ranging from 9 to 13, median equal to 9.0.

Table-4. Distribution of the studied cases according to GCS (n = 100).

	No.	%
GCS		
Moderate (9-13)	53	53.0
Severe(3-8)	47	47.0
Min. – Max.	3.0 – 13.0	
Mean ± SD.	8.73 ± 2.62	
Median	9.0	

Figure-4.Distribution of the studied cases according to GCS.



4. Distribution of patients according to mode of trauma:

The most common mode of trauma was RTA accounting for 73 patients while the least common mode of trauma was alleged assault accounting for 4 patients, falling from height accounted for 9 patients ,falling down accounted also for 9 patients while accidental falling of heavy object on the head accounted for 5 patients.

Table-5. Distribution of the studied cases according to mode of trauma and interval between trauma and first CT (n = 100).

	No.	%
Mode of trauma		
RTA	73	73.0
FFH	9	9.0
Falling of heavy object	5	5.0
Falling down	9	9.0
AA	4	4.0

Figure-5. Distribution of the studied cases according to mode of trauma and interval between trauma and first CT

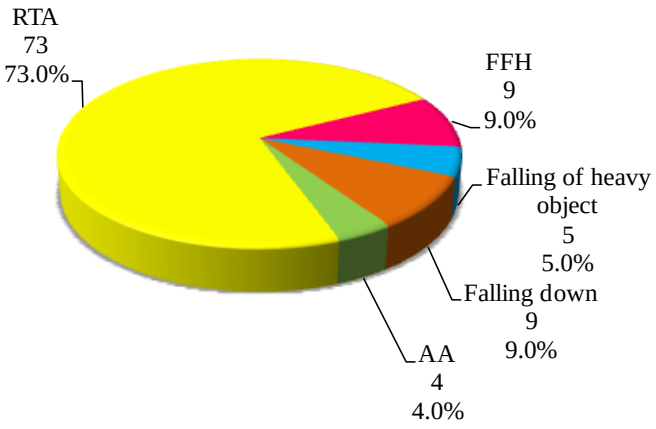
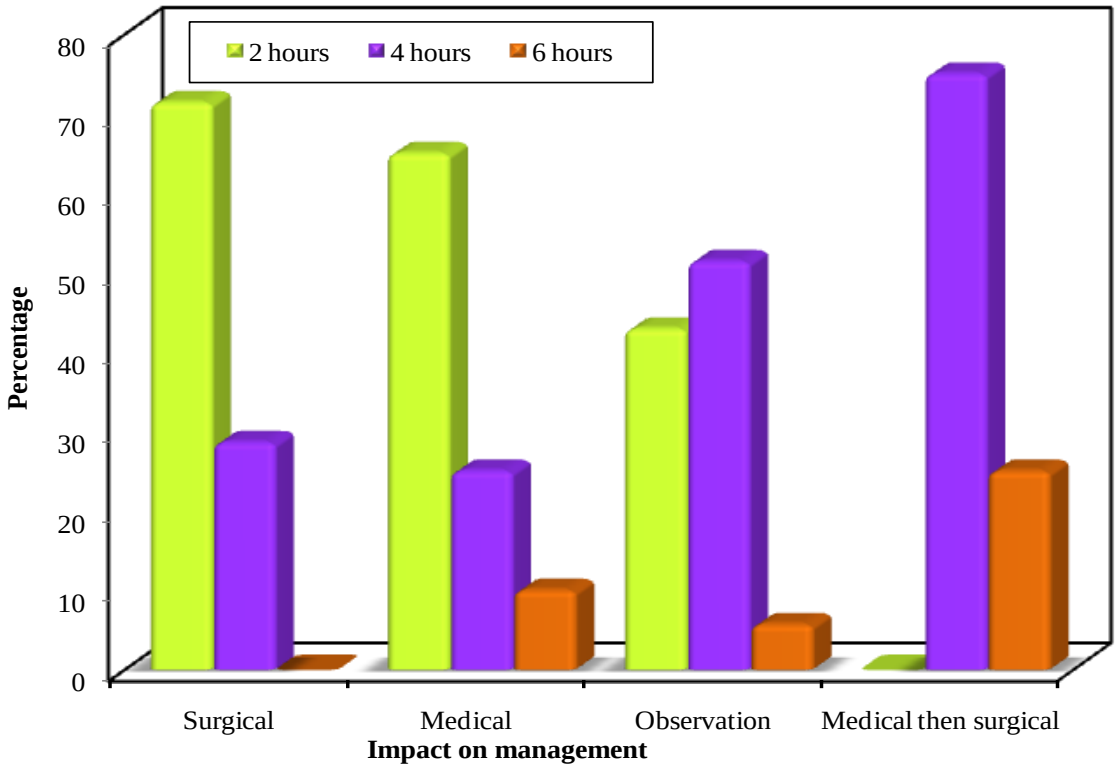


Table-7. Relation between Interval between timing of initial CT and impact on management

	Timing of initial CT						χ^2	^{MC}p
	2 hours (n = 56)		4 hours (n = 37)		6 hours (n = 7)			
	No.	%	No.	%	No.	%		
Impact on management								
Surgical	15	26.8	6	16.2	0	0.0	14.169*	0.014*
Medical	26	46.4	10	27.0	4	57.1		
Observation	15	26.8	18	48.6	2	28.6		
Medical then surgical	0	0.0	3	8.1	1	14.3		
Sig. bet. Periods	$^{MC}p_1$= 0.012*, $^{MC}p_2$=0.075, ^{MC}p3=0.293							

χ^2: Chi square test
MC: Monte Carlo for Chi square test
p_1: p value for comparing between 2 hours and 4 hours
p_2: p value for comparing between 2 hours and 6 hours
p_3: p value for comparing between 4 hours and 6 hours
*: Statistically significant at p ≤ 0.05

Figure-6. Relation between Interval between trauma and initial CT and impact on management



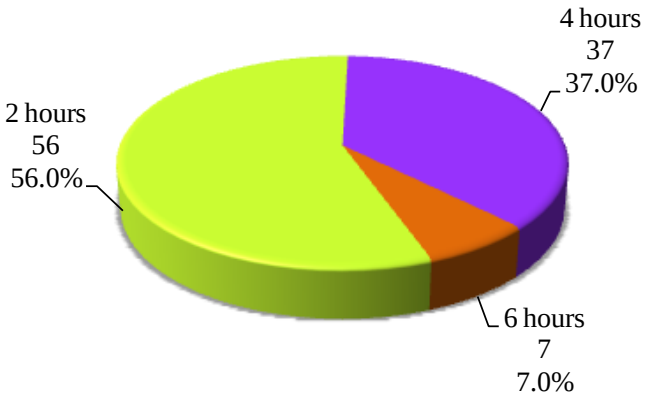
5. Distribution of patients according to the interval between trauma and the initial CT:

The majority of patients (73 patients) had their initial CT brain done 2 hours following the trauma incident while 37 patients after 4 hours of the trauma incident and 7 patients had it done after 6 hours.

Table-6. Distribution of the studied cases according to the interval between trauma and the initial CT brain (n=100).

Interval between trauma and initial CT	No.	%
2 hours	56	56.0
4 hours	37	37.0
6 hours	7	7.0
Mean ± SD.	3.03 ± 1.26	

Figure-7. Distribution of the studied cases according to the interval between trauma and the initial CT brain



6. Relation between timing of initial CT and impact on management:

In the 21 patients who had surgical intervention, 15 patients did their initial CT brain after 2 hours of the onset of trauma while only 6 patients had surgical intervention after 4 hours and none of the patients who undergo their CT after 6 hours of trauma had a surgical intervention.

In the 40 patients who received medical treatment (dehydration measures), 26 patients did their initial CT after 2 hours of the onset of trauma, 10 patients after 4 hours and only 4 patients who had their CT brain done after 6 hours received medical therapy after their follow up CT.

In the 4 patients who had medical then surgical intervention, 3 had their CT brain after 4 hours and 1 after 6 hours.

The highest significance was shown in the 2 hours period (p1=0.012), while the 4 hours and the 6 hours period was insignificant while the overall significance was high **(**p=0.014).

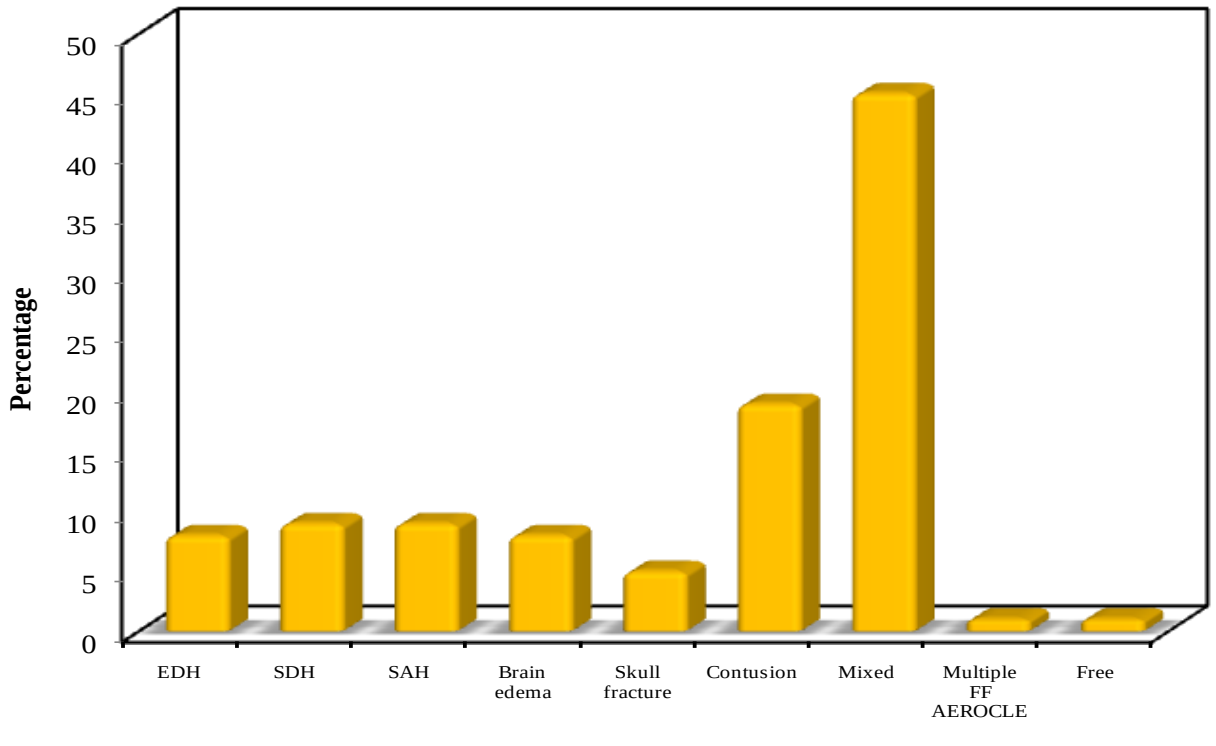
7. Distribution of patients according to the initial CT findings:

The studied cases were classified according to the finding in the initial CT brain most of the patients' initial CT brain show multiple lesions (45 patients), 19 patients show hemorrhagic contusion, 9 patients had SDH and other 9 patients had SAH in their initial CT brain, 8 patients had brain edema in their initial CT brain, 5 patients had skull fracture, 1 patient had multiple FF and aerocele while in 1 patient the initial CT brain was unremarkable.

Table-8. Distribution of the studied cases according to initial CT findings: (n = 100)

INITIAL CT BRAIN FINDING	No.	%
EDH	8	8.0
SDH	9	9.0
SAH	9	9.0
Brain edema	8	8.0
Skull fracture	5	5.0
Contusion	19	19.0

Figure-8. Distribution of the studied cases according to initial CT findings



Mixed	45	45.0
Multiple FF AEROCLE	1	1.0
Unremarkable	1	1.0

8. Relation between initial CT findings and findings in the follow up CT brain:

Analysis of the relation between indication initial CT brain finding and findings on follow up CT brain revealed that in 30 patients with increased size of their lesions on follow up CT brain 6 patients had EDH in their initial CT brain, 7 patients had SDH, 1 patient had SAH, 3 patients had brain edema, 1 patient had skull fracture, 2 patients have contusion and 12 patients had mixed lesions.

43 patients who showed new findings which was not present in their initial CT brain , 1 patient had EDH in their initial CT brain , 1 patient had SDH, 6 patients had SAH, 3 patients had brain edema, 4 patients had skull fracture, 11 patients had hemorrhagic contusion , 18 patients had mixed brain lesions while 1 patient had unremarkable CT brain.

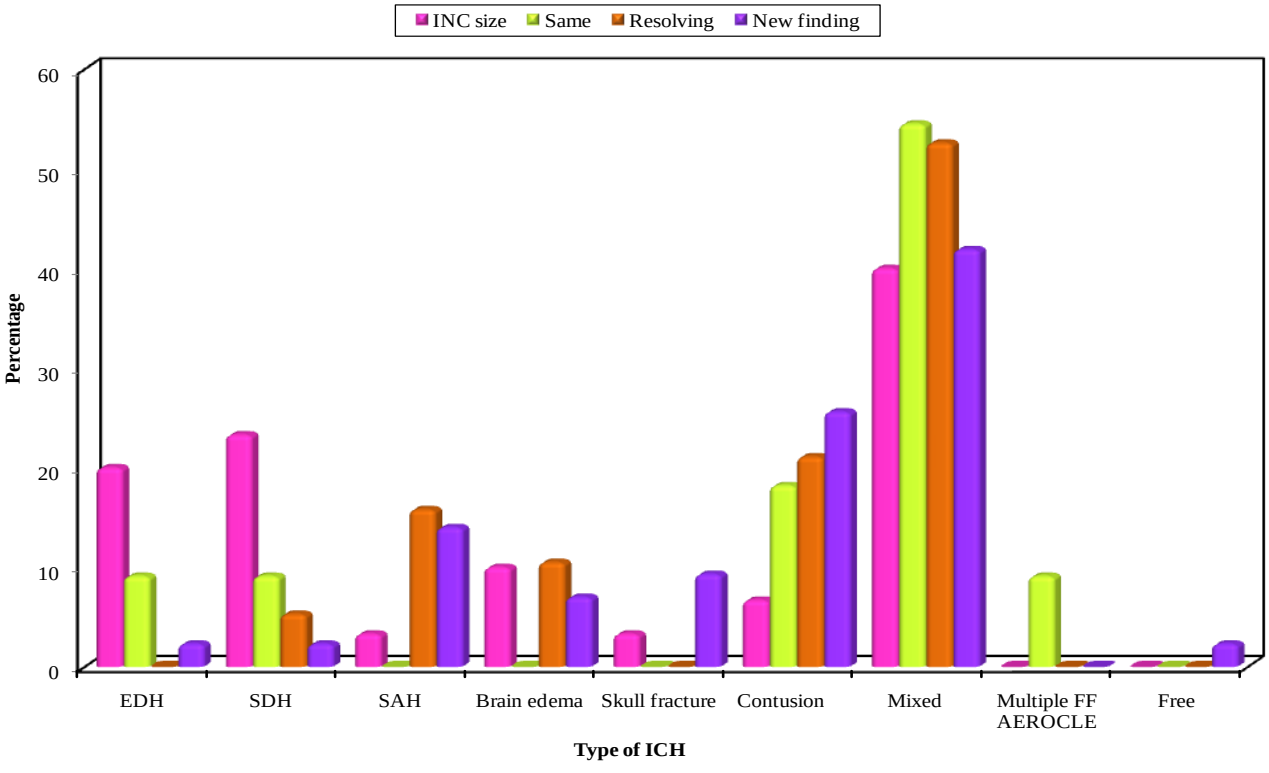
11 patients who remained the same on follow up CT

Table-9: Relation between initial CT brain finding and finding in follow up CT brain

Type of ICH	Finding in FU CT brain							
	INC size (n = 30)		Same (n = 11)		Resolving (n = 19)		New finding (n = 43)	
	No.	%	No.	%	No.	%	No.	%
EDH (n = 8)	6	20.0	1	9.1	0	0.0	1	2.3
SDH (n = 9)	7	23.3	1	9.1	1	5.3	1	2.3
SAH (n = 9)	1	3.3	0	0.0	3	15.8	6	14.0
Brain edema (n = 8)	3	10.0	0	0.0	2	10.5	3	7.0
Skull fracture (n = 5)	1	3.3	0	0.0	0	0.0	4	9.3
Contusion (n = 19)	2	6.7	2	18.2	4	21.1	11	25.6
Mixed (n = 45)	12	40.0	6	54.5	10	52.6	18	41.9
Multiple FF AEROCLE (n = 1)	0	0.0	1	9.1	0	0.0	0	0.0
Free (n = 1)	0	0.0	0	0.0	0	0.0	1	2.3
^{MC}p	0.001*		0.438		0.748		0.031*	

χ^2: Chi square test; MC: Monte Carlo for Chi square test; *: Statistically significant at p ≤ 0.05

Figure-9. Relation between initial CT brain finding and finding in follow up CT brain



brain, 1 patient had EDH, 1 patient had SDH, 6 patients had mixed lesions, and 1 patient had multiple fissure fracture and aerocele while 2 patients had hemorrhagic contusion.

19 patients whose initial lesions were resolving follow up CT brain, 1 patient had SDH, 3 patients had SAH, 2 patients had brain edema, 4 patients had hemorrhagic contusion while 10 patients had mixed lesions.

The p value was significant in those patients who show new changes in their follow up CT brain with p value =0.031 and those who show increase in the size of their lesions with p value =0.001.

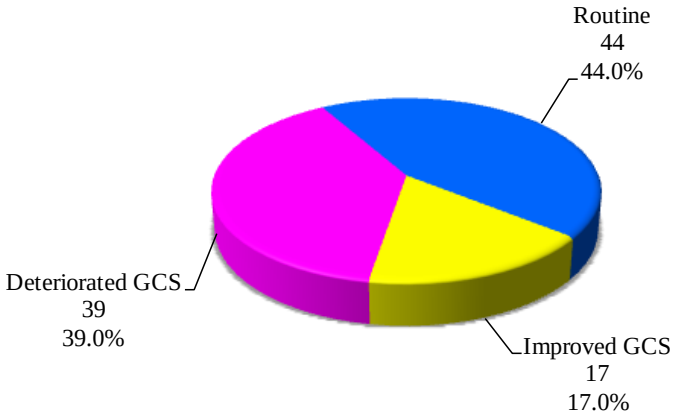
9. Distribution of patients according to indication of follow up CT brain:

Patients included in the study were classified according to the indication of their follow up CT brain, 44 patients have their follow up CT brain done as a routine follow up while 39 patients have it done as a result of deteriorated GCS and 17 patients have it done as a result of improved GCS.

Table-10. Distribution of patients according to the indication of follow up CT brain (n=100)

Indication of follow up	No.	%
Routine	44	44.0
Improved GCS	17	17.0
Deteriorated GCS	39	39.0

Figure-10. Distribution of patients according to the indication of follow up CT brain



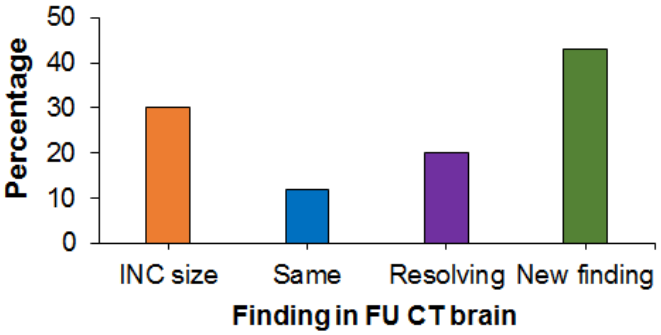
10. Distribution of patients according to findings in follow up CT brain:

Patients included in the study were classified according to the findings in their follow up CT BR as follows: the most encountered finding was appearance of a new lesion which was in 43 patients followed by increase in the size of the new lesions in 30 patients, resolving of the initial lesion was encountered in 19 patients and the FU CT brain remains the same as the initial in 11 patients.

Table-11. Distribution of the studied cases according to new findings in follow up CT BRAIN (n = 100)

Finding in FU CT brain	No.	%
INC size	30	30.0
Same	11	11.0
Resolving	19	19.0
New finding	43	43.0

Figure-11. Distribution of the studied cases according to new findings in follow up CT BRAIN



11. Relation between indication of follow up CT and findings in follow up CT:

In the 30 patients who showed increase in the size of initial lesions in follow up CT brain, 14 had their follow up CT on routine basis while 16 had it routinely while 16 patients had it due to change in GCS(deteriorated GCS).(p value=0.725).

In the 43 patients who showed new findings in their follow up CT brain, 19 had it routinely while 24 patients had it due to change in GCS(deteriorated GCS).(p value=0.974).

In the 11 patients whose their follow up CT remained the same as the initial CT , 9 had their follow up CT routinely while 2 had it due to change in GCS(improving GCS).(p value= 0.01).

In the 19 patients who showed resolving lesions in , 4 patients had it routinely while 15 had it due to change in GCS where all them was improving GCS.(p value=0.025).

12. Distribution of the studied cases according to impact on management:

The patients included in the study were classified according to impact of FU CT finding on management it was found that 21 patients undergo surgery according to their follow up CT brain finding ,40 patients received medical therapy as dehydrating measures after undergoing their follow up CT brain finding ,4 patients received medical treatment then after further follow up CT brain they undergo surgery ,35 patients were under

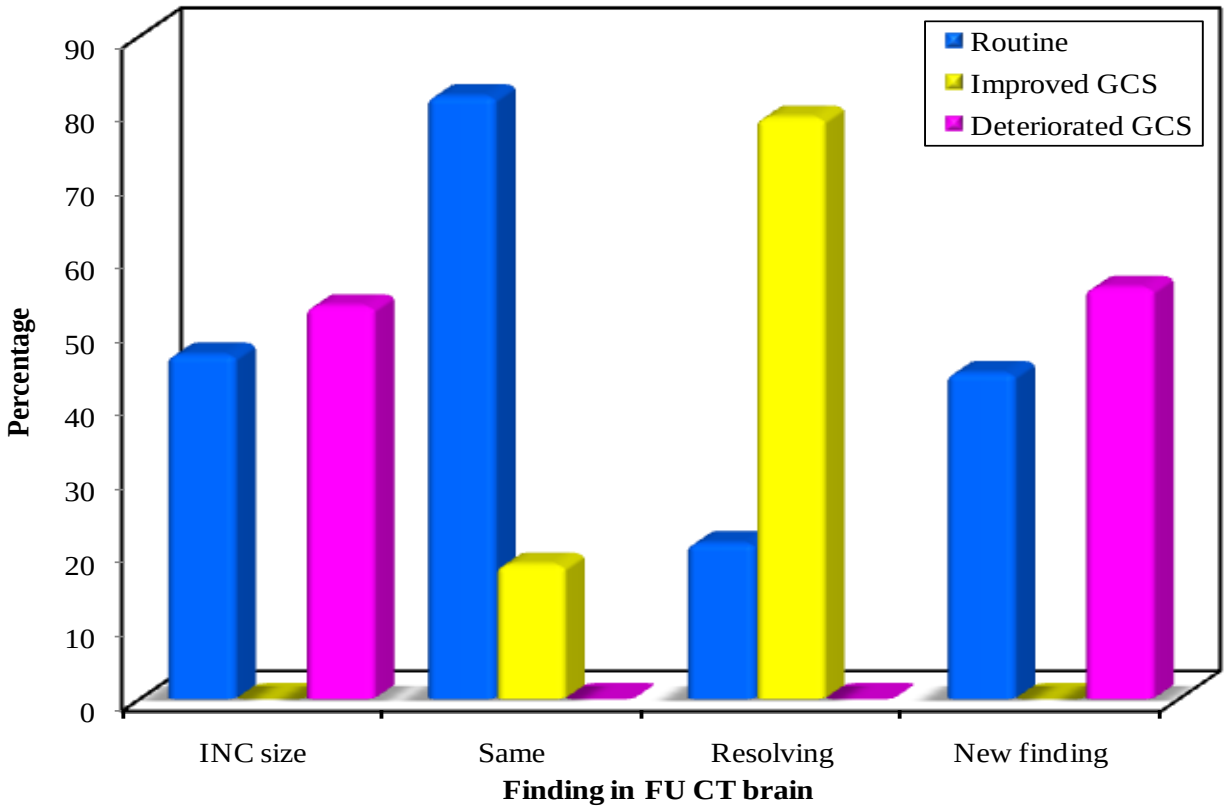
Table-12. Relation between indication of FU CT brain and finding in follow up CT BRAIN

Indication of FU CT brain	Finding in FU CT brain							
	INC size (n = 30)		Same (n = 11)		Resolving (n = 19)		New finding (n = 43)	
	No.	%	No.	%	No.	%	No.	%
Routine (n = 44)	14	46.7	9	81.8	4	21.1	19	44.2
Change in GCS (n =56)	16	53.3	2	18.2	15	78.9	24	55.8
P	P=0.725		^{FE}p=0.010*		P=0.025*		P=0.974	

χ^2: Chi square test; MC: Monte Carlo for Chi square test; *: Statistically significant at p ≤ 0.05

Cause of FU CT brain	Finding in FU CT brain							
	INC size (n = 30)		Same (n = 11)		Resolving (n = 19)		New finding (n = 43)	
	No.	%	No.	%	No.	%	No.	%
Routine	14	46.7	9	81.8	4	21.1	19	44.2
Improved GCS	0	0.0	2	18.2	15	78.9	0	0.0
Deteriorated GCS	16	53.3	0	0.0	0	0.0	24	55.8

Figure-12. Relation between indication of FU CT brain and finding in follow up CT BRAIN

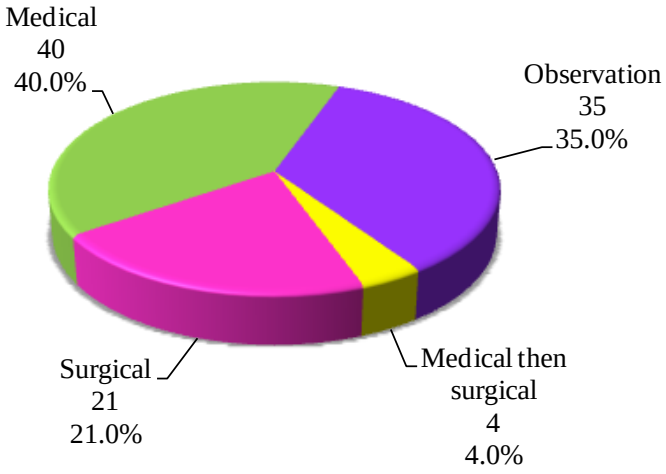


observation with no impact for follow up CT brain on these patients' management.

Table-13. Distribution of the studied cases according to impact on management (n= 100)

Impact on management	No.	%
Surgical	21	21.0
Medical (dehydration measures	40	40.0
Observation	35	35.0
Medical then surgical	4	4.0

Figure-13. Distribution of the studied cases according to impact on management



13. Relation between indication of follow up CT brain and impact on management:

Analysis of the relation between indication of follow up CT brain and impact on management revealed that in the 21 patients who were managed surgically, 12 patients (57%) had their follow up CT upon change in GCS(deteriorated GCS), 9 patients (42.9%) had their follow up CT on routine basis .(p value= 0.9**).** In the 40 patients who were managed medically, 25 (62.5%) patients had their follow up CT upon change in GCS (deteriorated GCS), 15 patients (37.5%) had their follow up CT on routine basis (p value=0.28). In the 4 patients who were managed medically then surgically 2 did it routinely & 2 where upon GCS change (GCS deterioration) (p value=1). In the 35 patients who were observed, 17 patients (48.6%) had their follow up CT upon GCS change (improved GCS) while 18 patients (51.4%) had their follow up CT on routine basis (p value=0.27).

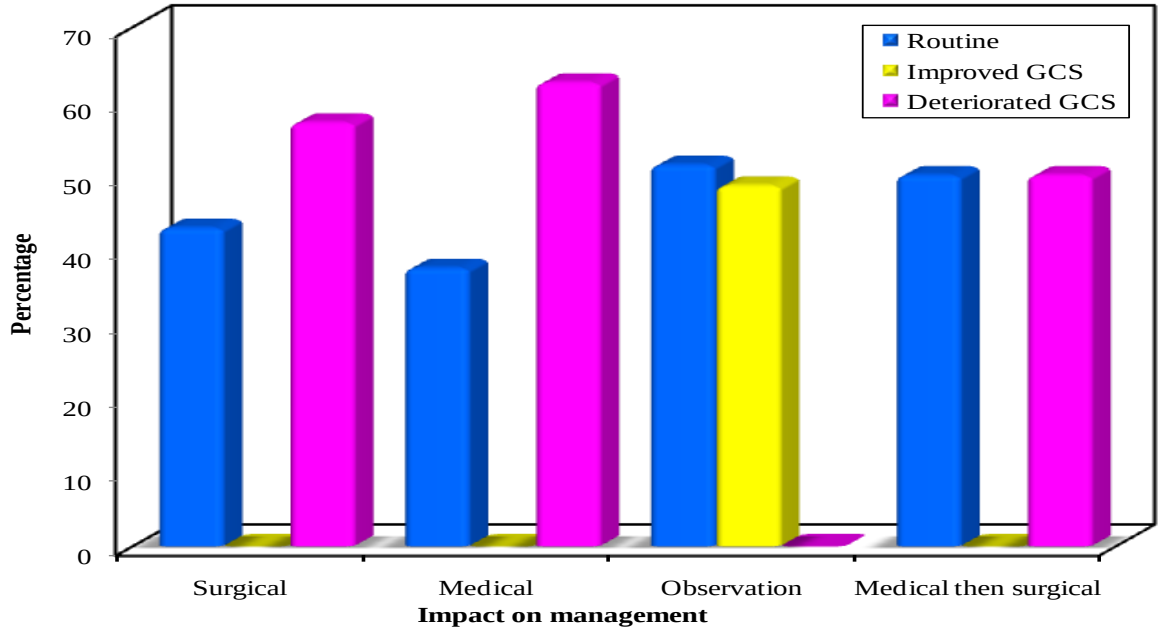
Table-14. Relation between indication for follow up CT and impact on management.

Indication	Impact on management							
	Surgical (n = 21)		Medical (n = 40)		Observation (n = 35)		Medical then surgical (n = 4)	
	No.	%	No.	%	No.	%	No.	%
Routine (n = 44)	9	42.9	15	37.5	18	51.4	2	50.0
Change in GCS (n =56)	12	57.1	25	62.5	17	48.6	2	50.0
P value	0.906		0.285		0.272		1.000	

χ^2: Chi square test; MC: Monte Carlo for Chi square test; *: Statistically significant at p ≤ 0.05

Indication	Impact on management							
	Surgical (n = 21)		Medical (n = 40)		Observation (n = 35)		Medical then surgical (n = 4)	
	No.	%	No.	%	No.	%	No.	%
Routine	9	42.9	15	37.5	18	51.4	2	50.0
Improved GCS	0	0.0	0	0.0	0	0.0	0	0.0
Deteriorated GCS	12	57.1	25	62.5	17	48.6	2	50.0

Figure-14. Relation between indication for follow up CT and impact on management



14. Relation between indication of follow up, severity of TBI and impact on management:

In the 53 patients with moderate TBI, 12 patients had surgical intervention of which 9 had their follow up CT brain done on basis of GCS deterioration and 3 had their follow up CT brain done routinely, 20 patients had medical intervention, of which 16 had their follow up CT brain on basis of GCS deterioration and 4 patients had their follow up CT brain routinely.

In the 47 patients with severe TBI, 13 patients had surgical intervention of which 5 patients did their follow up CT brain on basis of GCS deterioration and 8 patients did it routinely, 20 patients had medical intervention of which 8 patients did their follow up CT brain on basis of GCS deterioration and 12 patients did it routinely.

15. Distribution of the patients according to the timing of the first follow up CT brain:

Patients included in the study were classified according to the timing of their first follow up CT brain, according to the timing of the follow up CT brain, 7 patients undergo a follow up with thin 2 hours, 24 patients undergo a follow up with thin 4 hours while 29 patients undergo a CT brain with thin 6 hours and 26 patients undergo a follow up with thin 12 hours.

Table-16. Distribution of the studied cases according to timing of follow up CT brain (n = 100).

Timing of first follow up CT brain	No.	%
2 hours	7	7.0
4 hours	24	24.0
6 hours	29	29.0
12 hours	36	36.0
24 hours	4	4.0
Mean ± SD.	8.12 ± 4.87	

Table-15. Relation between indication of follow up CT brain, severity of TBI and impact on management.

IMPACT ON MANGMENT	SEVERITY OF TBI			
	MODERATE		SEVERE	
	ROUTINE	GCS DETRIORATION	ROUTINE	GCS DETERIORATION
Surgical	3	9	8	5
Medical	4	16	12	8
Observation	12	9	8	6

Figure-15. Relation between indication of follow up CT brain, severity of TBI and impact on management

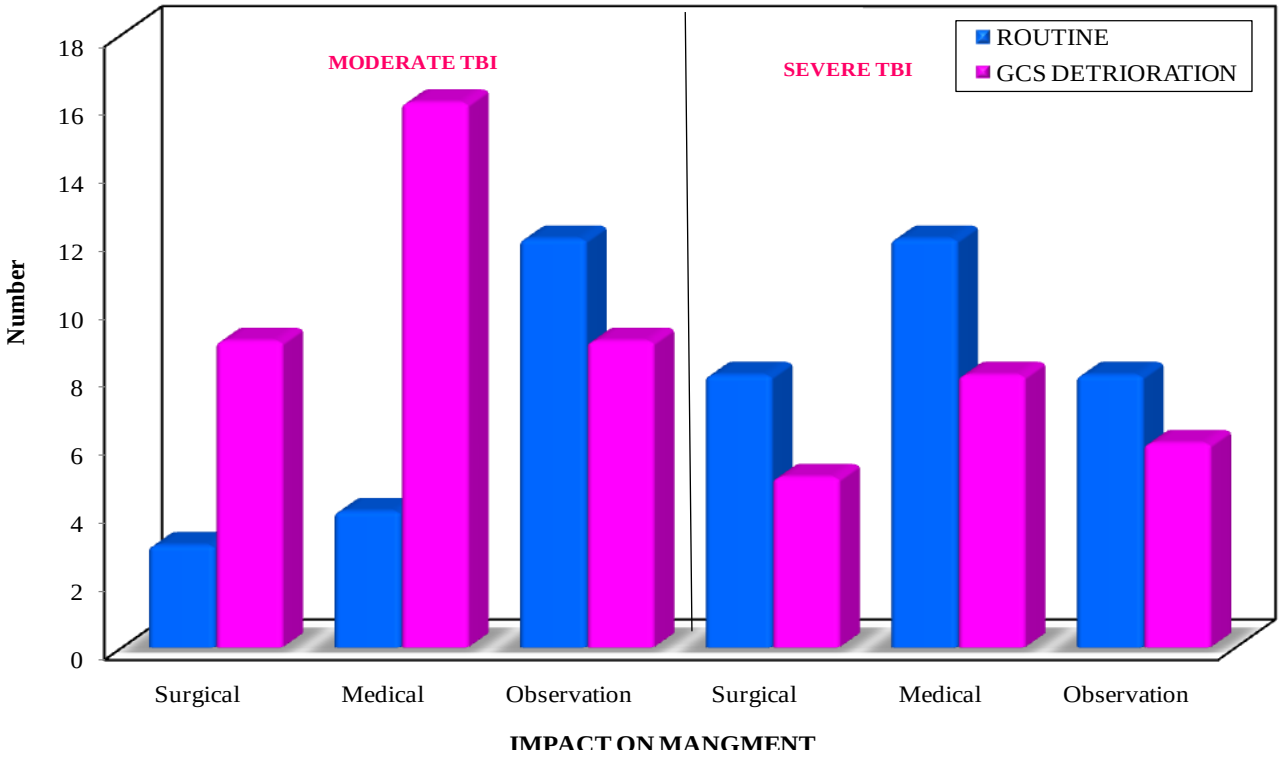
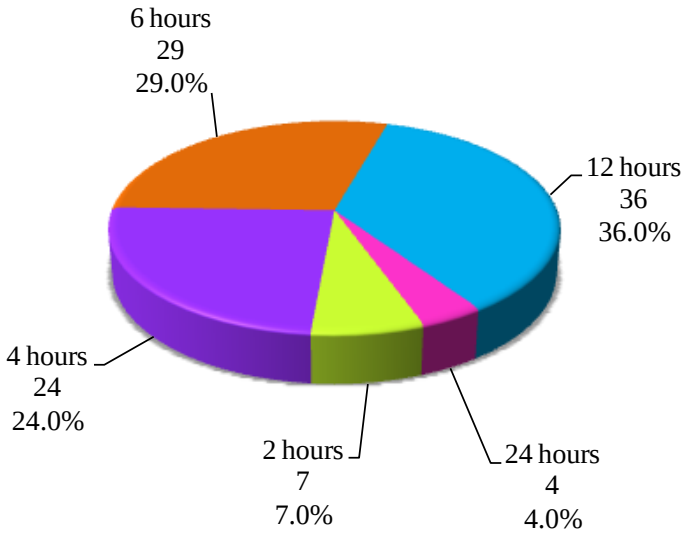


Figure-16. Distribution of the studied cases according to timing of follow up CT brain.



16. Relation between the timing of the first follow up CT brain and the impact on management:

Analysis of the relation between timing of first follow up CT brain and impact on management revealed that, 21 patients who had surgery the timing of follow up CT brain was 2 hours in 6 patients, 4 hour in 9 patients, 6 hours in 5 patients and 12 hours in 1 patient, it shows high statistical significance with p<0.001 shown mainly in 2 and 4 hours interval.

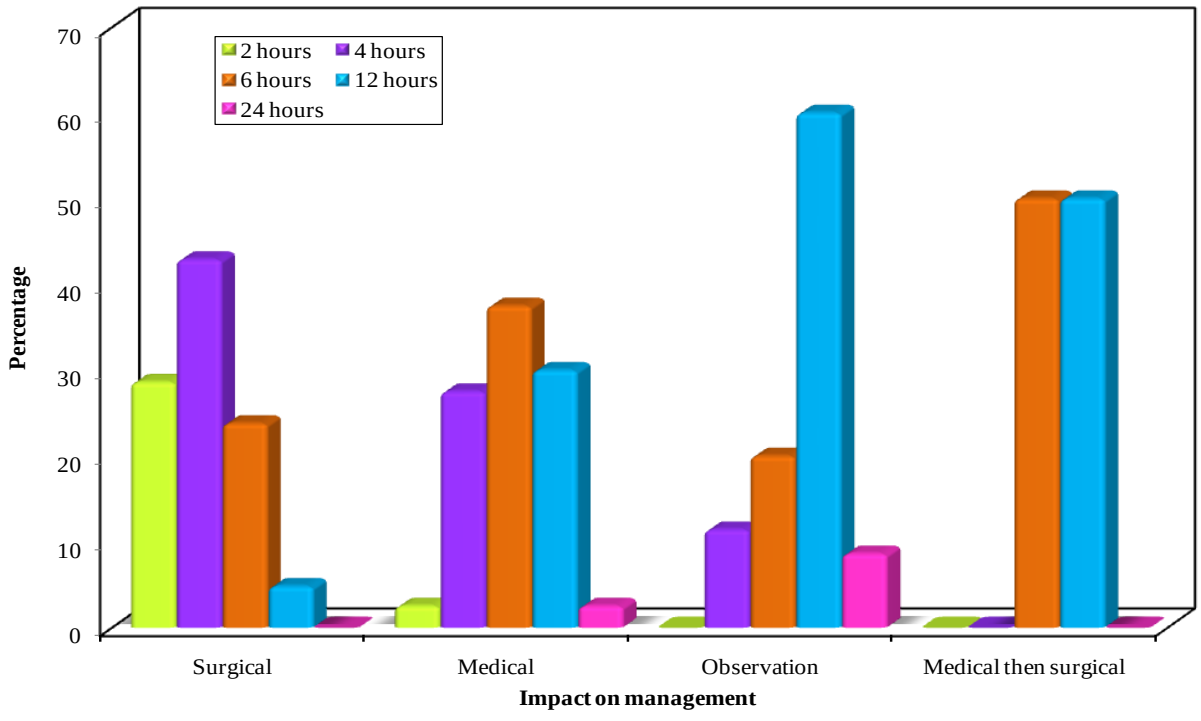
In 40 patients who received medical therapy the timing of follow up CT brain was 2 hours in 1 patient,4 hours in 11 patients,6 hours in 15 patients,12 hours in 12 patients and 24 hours in 1 patient, no statistical significance,(p=0.31), shown between different intervals for follow up CT in this patients .

35 patients who were observed in ICU the timing of follow up CT brain was 4 hours in 4 patients,6 hours in 7 patients,12 hours in 21 patients and 24 hours in 3 patients, high statistical significance (p<0.001) was

Table-17. Relation between timing of first follow up CT brain and impact on management.

Timing of initial FU CT brain	Impact on management								χ^2	^{MC}p
	Surgical (n = 21)		Medical (n = 40)		Observation (n = 35)		Medical then surgical (n = 4)			
	No.	%	No.	%	No.	%	No.	%		
2 hours (n = 7)	6	28.6	1	2.5	0	0.0	0	0.0	36.517*	<0.001*
4 hours (n = 24)	9	42.9	11	27.5	4	11.4	0	0.0		
6 hours (n = 29)	5	23.8	15	37.5	7	20.0	2	50.0		
12 hours (n = 36)	1	4.8	12	30.0	21	60.0	2	50.0		
24 hours (n = 4)	0	0.0	1	2.5	3	8.6	0	0.0		
^{MC}p	<0.001*		0.311		<0.001*		0.728			

Figure-17. Relation between timing of first follow up CT brain and impact on manage



observed shown mainly in 12 hours timing.

4 patients who were managed medically then surgically follow up CT brain was done after 6 hours in 2 patients and after 12 hours in 2 patients, no statistical significance was shown (p=0.7).

The relation between timing of follow up CT brain and impact on management revealed that timing of follow up CT brain was directly proportional to the timing of follow up CT brain with p value less than 0.001 which is considered statistically highly significant.

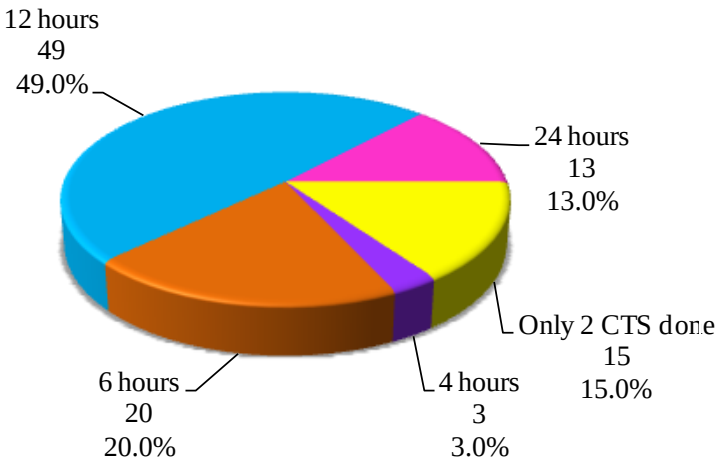
17. Distribution of patients according to the interval between CT brain 2 and serial CTs:

The studied cases were distributed according to the interval between CT brain 2 and serial CTs ,in most of the patients the interval was 12 hours (49 patients) while it was 6 hours in 20 patients , 24 hours in 13 patients and 4 hours in 3 patients, in 15 patients only one follow up CT brain was done.

Table-18. Distribution of the studied cases according to interval between CT BR 2 and serial CT scan (n = 100).

Interval between CT BR 2 and serial CTS	No.	%
Only 2 CTS done	15	15.0
4 hours	3	3.0
6 hours	20	20.0
12 hours	49	49.0
24 hours	13	13.0

Figure-18. Distribution of the studied cases according to interval between CT BR 2 and serial CT scan



18. Relation between intervals between CT brain 2 and serial CTs and impact on management:

Analysis of the relation between interval between CT brain 2 and serial CTS with impact on management of patients, in 21 patients who were managed surgically, the interval between CT brain 2 and serial CTs was as follows: 2 hours in 11 patients, 4 hours in 2 patients, and 6 hours in 8 patients with high statistical significance (p<0.001).

In 40 patients who were managed medically the interval between CT brain 2 and serial CTs was as follow: 6 hours in 8 patients, 12 hours in 27 patients and 24 hours in 5 patients showing high statistical significance(p <0.001).

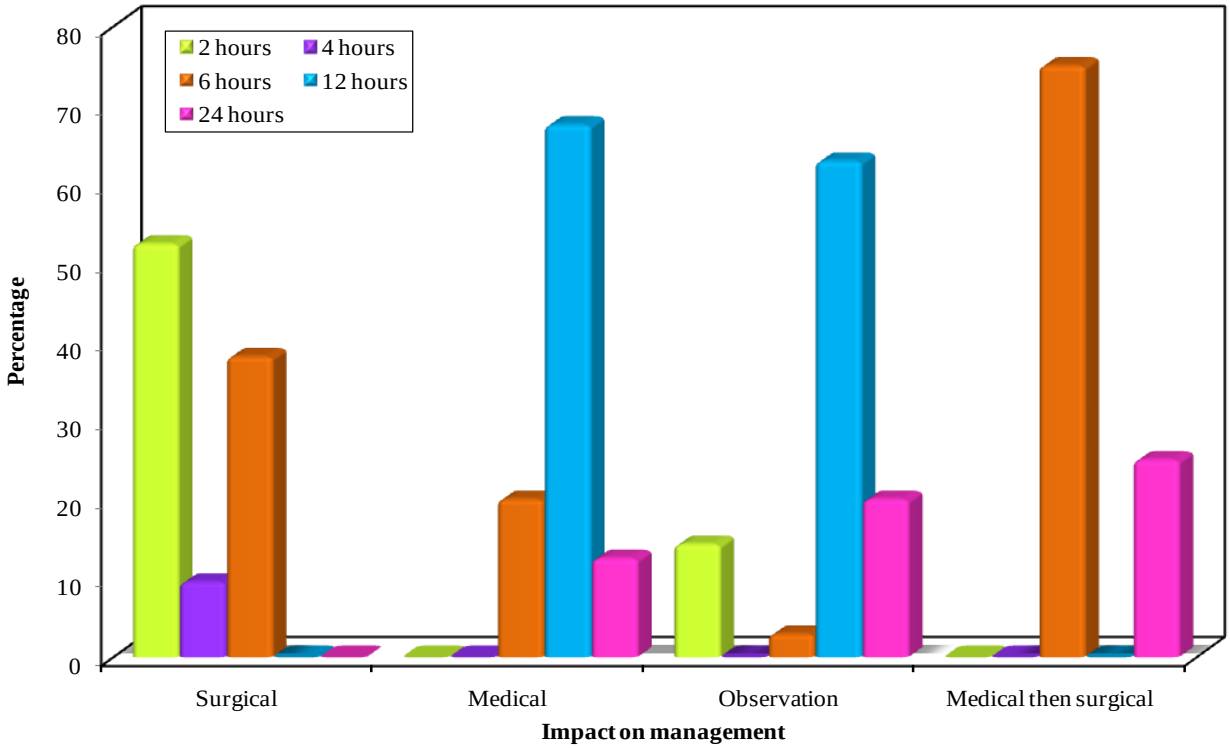
In 35 patients who were observed in ICU, the interval between CT brain 2 and serial CTs was as follow: 2 hours in 5 patients, 6 hours in 1 patient, 12 hours in 22 patients and 24 hours in 7 patients showing high statistical significance(p=0.003).

Table-19. Relation between interval between the CTs following the first follow up CT brain and impact on management

Interval between FU CT BR following the first follow up	Impact on management								χ^2	^{MC}p
	Surgical (n = 21)		Medical (n = 40)		Observation (n = 35)		Medical then surgical (n = 4)			
	No.	%	No.	%	No.	%	No.	%		
2 hours (n = 16)	11	52.4	0	0.0	5	14.3	0	0.0		
4 hours (n = 2)	2	9.5	0	0.0	0	0.0	0	0.0		
6 hours (n = 20)	8	38.1	8	20.0	1	2.9	3	75.0	68.451*	<0.001*
12 hours (n = 49)	0	0.0	27	67.5	22	62.9	0	0.0		
24 hours (n = 13)	0	0.0	5	12.5	7	20.0	1	25.0		
^{MC}p	<0.001*		<0.001*		0.003*		0.035*			

χ^2: Chi square test; MC: Monte Carlo for Chi square test; *: Statistically significant at p ≤ 0.05

Figure-19. Relation between interval between the CTs following the first follow up CT brain and impact on management



In 4 patients who were managed medically then surgically, the interval between CT brain 2 and serial CTs was as follow: 6 hours in 3 patients and 24 hours in 1 patient showing high statistical significance (p=0.003) The correlation between the interval between CT brain 2 and serial CTs and the impact on management of patients revealed that there is direct proportional between both of them with p value less than 0.001 which is considered statistically highly significant.

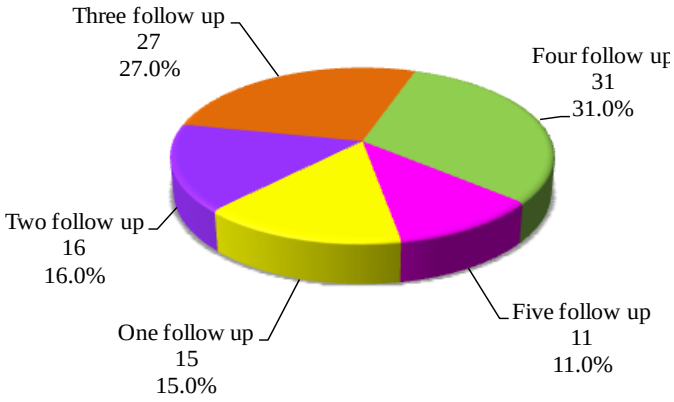
19. Distribution of patients according to number of CT brain done:

The number of follow up CT BRS done to the patients in the study was recorded as follows 15 patients undergo 1 follow up CT , 16 patients undergo 2 follow up CT , 27 patients undergo 3 follow up CT brain, 31 patients undergo 4 follow up CT brain while 11 undergo 5 follow up CT brain.

Table-20. Distribution of the studied cases according to number of CT brain done (n=100).

Number of FU CT brain	No.	%
One follow up	15	15.0
Two follow up	16	16.0
Three follow up	27	27.0
Four follow up	31	31.0
Five follow up	11	11.0
Mean ± SD.	3 ± 1	

Figure-20. Distribution of the studied cases according to number of CT brain done



20. Distribution of patients according to follow up CT number where changes were encountered:

Changes in the follow up CT brain were classified according to the follow up CT number it was encountered in where most of the changes was in CT BR 2 (59 patients), 18 patients in CT BR 3, 11 patients in CT BR 2 & 3 while 11 patients remains the same with no changes in any of the CT BR which was done.

21. Follow up CT brain upon which management take place:

In the medical group (40 patients), most of the management was decided upon CT brain 2 (27 patients) followed by CT brain 3 (11 patients).

In the surgical group (21 patients), most of the management was decided upon CT brain 2 (11 patients) and CT brain 3 (10 patients).

In the medical then surgical group (4 patients), medical management was given upon CT brain 2 followed by surgery at CT brain 3.

Table-21. Distribution of patients according to follow up CT number where changes was encountered (n=100).

Changes in which FU CT brain	NO.	%
CT BR 2	59	59.0
CT BR 3	18	18.0
CT BR 2 and 3	11	11.0
CT BR 4	1	1

NB: 11 patients has no changes of their lesions on follow up CT

Figure-21. Distribution of patients according to follow up CT number where changes was encountered

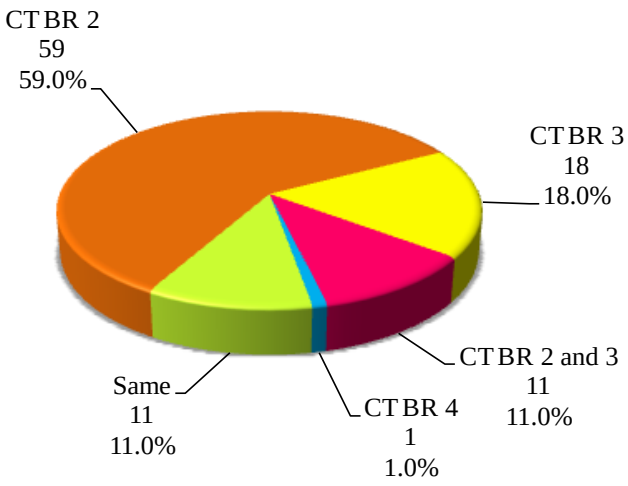


Figure-22. Change of management upon which follow up CT brain

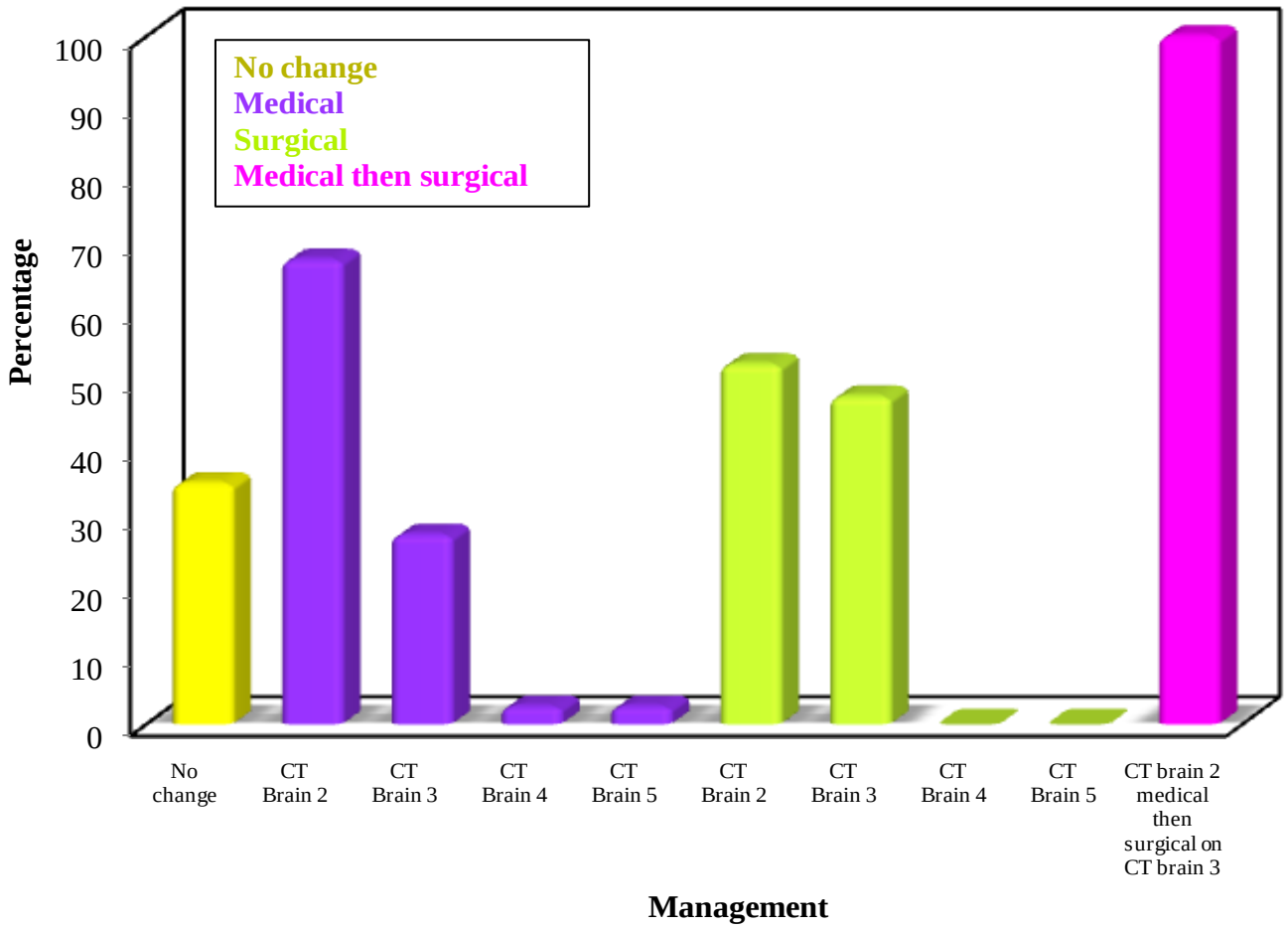


Table-22. Change of management upon which follow up Ct brain (n = 100).

Management	No.	%
No change	**35**	**35.0**
Medical	**40**	**40.0**
CT Brain 2	27	67.5
CT Brain 3	11	27.5
CT Brain 4	1	2.5
CT Brain 5	1	2.5
Surgical	**21**	**21**
CT Brain 2	11	52.3
CT Brain 3	10	47.6
CT Brain 4	0	0.0
CT Brain 5	0	0.0
Medical then surgical	**4**	**4**
CT brain 2 medical then surgical on CT brain 3	4	100

22. Timing of follow up CT brain at which management take place:

In the medical group (n=40), the most common Timing of follow up CT brain at which intervention take place was 12 hours in 12 patients followed by 6 hours in 10 patients and 4 hours in 9 patients.

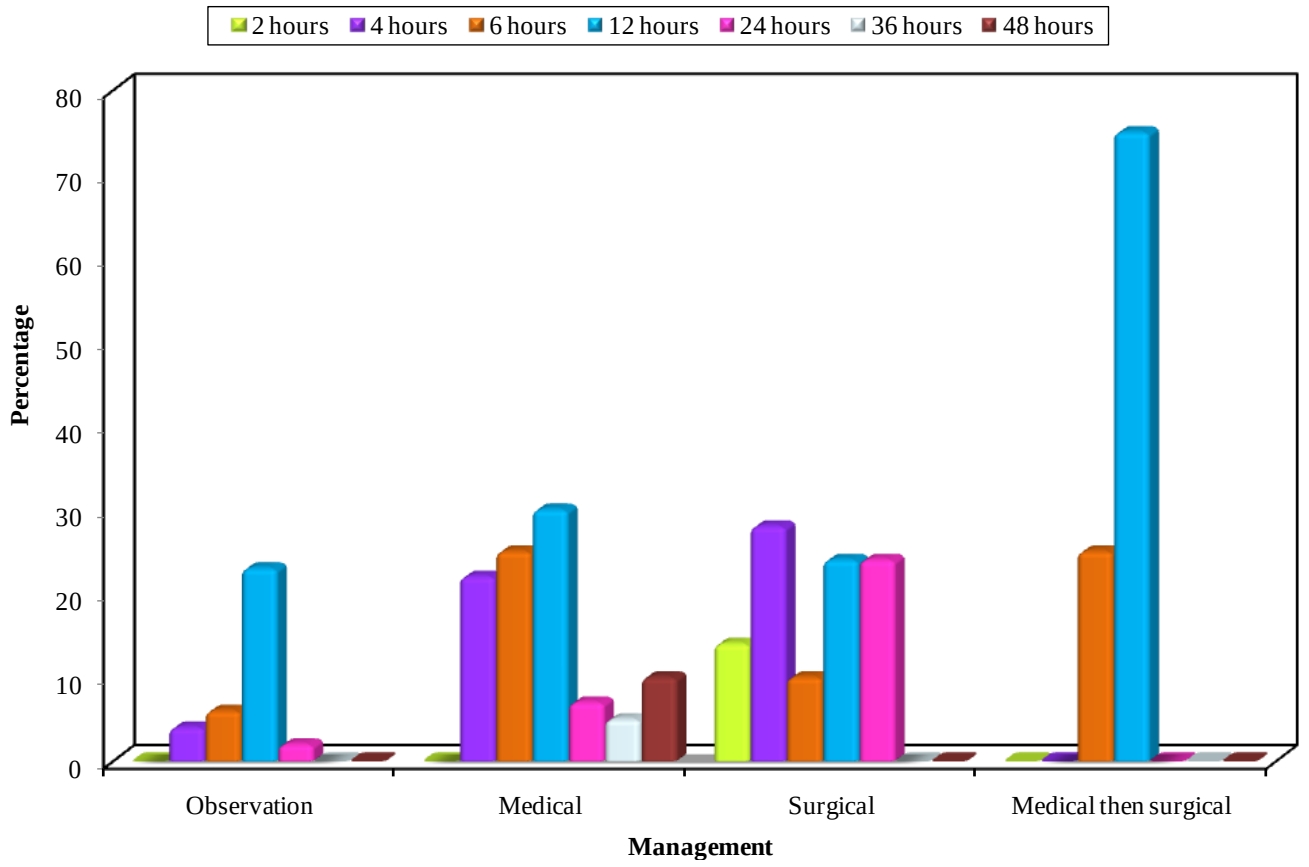
The majority of the follow up CT at which surgical intervention was done (n=21) was those arranged at 4 hours interval from the initial CT done (6 patients) followed by those arranged at 12 hours (5 patients) and 24 hours (5 patients).

In the 4 patients with medical followed by surgical management, 1 patient with follow up CT impacting management done at 6 hours, the other 3 patients had their follow up CT at 12 hours.

Table-23. Timing of follow up Ct brain at which management take place (n = 100)

Management	No.	%
Observation	35	35
4 hours	4	4.0
6 hours	6	6.0
12 hours	23	23.0
24 hours	2	2.0
Medical	40	40
4 hours	9	22%
6 hours	10	25%
12 hours	12	30%
24 hours	3	7%
36 hours	2	5%
48 hours	4	10%
Surgical	21	21
2 hours	3	14%
4 hours	6	28%
6 hours	2	10%
12 hours	5	24%

Figure-23. Change of management upon which follow up CT brain



24 hours	5	24%
Medical then surgical	4	
6 hours	1	25%
12 hours	3	75%

23. Distribution of patients according to changes of follow up CT brain after 48 hours:

On assessing the follow up CT brain done after 48 hours to the patients included in the study: 20 patients have no changes than the preceding CT brain,26 patients' lesions were resolving while only 10 patients has new findings that was not encountered in the preceding ones.40 patients did not undergo a follow up CT brain after 48 hours.

Table-24. Distribution of the studied cases according to finding of follow up CT brain after 48 hours (n=100)

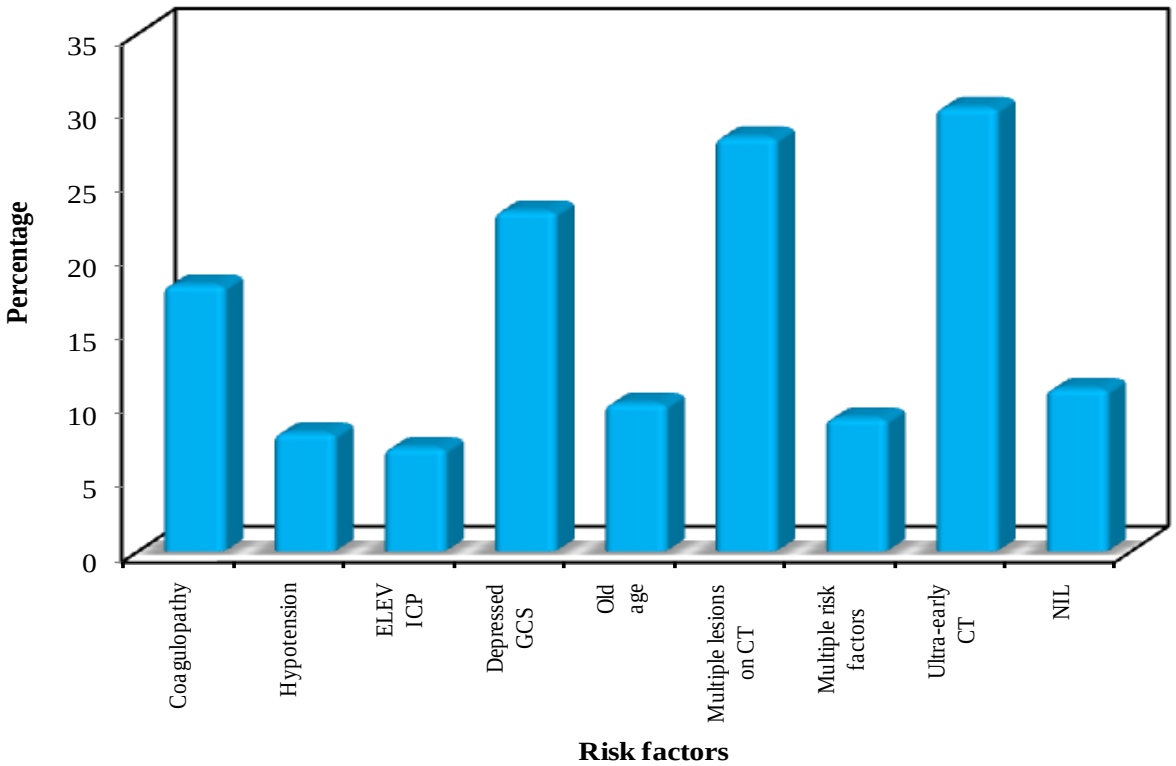
Finding after 48 hours	NO.	%
Same	24	24.0
New finding	10	10.0
Resolving	26	26.0
Not done	40	40.0

Figure-24. Distribution of the studied cases according to finding of follow up CT brain after 48 hours

24. Distribution of patients according to the presence of risk factors for progression of lesions on follow up CT brain:

The patients included in the study were classified according to the presence of risk factors for progression of lesions on follow up CT brain: 18 patients had coagulopathy, 23 patients has low GCS, 28 patients have multiple lesions on initial CT brain, 30 patients have an ultra-early initial CT brain, 10 patients are old age (more than 60 years old), 8 have hypotension, 7

Figure-25. Distribution of the studied cases according to risk factors



patients have hydrocephalus, 9 patients have multiple risk factors while 11 patients did not have any risk factors.

Table-25. Distribution of the studied cases according to risk factors (n = 100).

Risk factors	No.	%
Coagulopathy	18	18.0
Hypotension	8	8.0
Hydrocephalus	7	7.0
Low GCS	23	23.0
Old age	10	10.0
Multiple lesions on CT	28	28.0
Multiple risk factors	9	9.0
Ultra-early CT	30	30.0
NIL	11	11.0

25. The relation between risk factors for progression of follow up CT brain findings and findings on follow up CT brain:

Analysis of the relation between risk factors for progression of follow up CT brain findings and findings on follow up CT brain revealed that, In the 30 patients whose follow up CT showed increased size of their initial lesions, 6 patients had coagulopathy, 3 patients were hypotensive, 3 patients had elevated ICP,10 patients had depressed GCS,10 patients had multiple lesions on CT brain, 10 patients had multiple lesions on initial CT brain,5 patients had multiple risk factors 12 patients did their CT brain very early and 1 patient did not have any risk factors, the p value = 0.117 (not statistically significant).

In the 43 patients whose follow up CT showed new findings, 12 patient had coagulopathy, 5 patients were hypotensive, 1 patient had increased ICP**,** 1 patient had coagulopathy, 7 patients had low GCS, 8 patients were old age, 10 patients had multiple lesions on their initial CT brain.**,** 17 patients had an early initial CT brain, 3 patients had multiple risk factors and 2 patients had no risk factors, the p value= 0.01 which is statistically significant.

In the 19 patients whose follow up CT showed resolving lesions on follow up CT brain 1 patients had coagulopathy, 4 patients had hydrocephalus, 2 patients had low GCS, 6 had multiple lesions on initial CT brain, 1 did an early initial CT brain and 6 patients had no risk factors, the p value is 0.001 which is statistically significant.

In the 11 patients whose follow up CT remained the same, 4 patients had low GCS, 2 were old age, 2 had multiple lesions in the initial CT brain, 1 did an early initial CT brain and 3 patients had no risk factors, the p value =0.115 which is not statistically significant.

Discussion

The management of head trauma patients is a great issue that greatly affect the morbidity and mortality of trauma victims. One of the main aspects of good neuro trauma management for these patients is continuous assessment for progression of post-traumatic hematomas and evolution of new lesions with early intervention in order to give the best chance for improvement and survival .(Smith et al., 2007).

In the current study we would discuss the timing of follow up CT brain whether it was done routinely or on basis of GCS and the evolution of initial lesions on serial CTs done in a trial to clarify the impact of a timely follow up CT brain on the management of moderate and severe traumatic brain injuries.

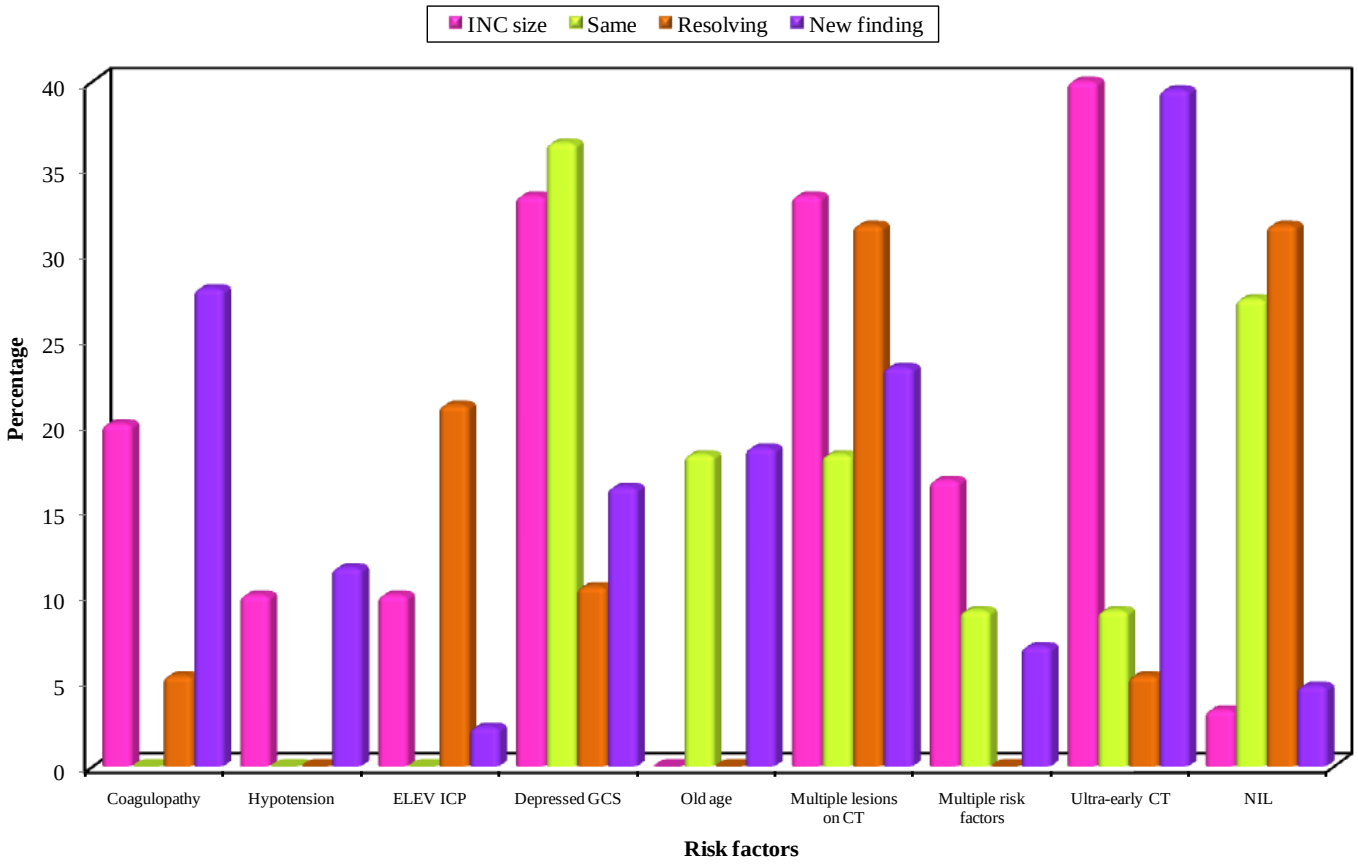
In the current study, it was noticed that the percentage of male patients is higher than the percentage of female patients (82% versus 18% respectively). This reflects that males are more prone than females to poly-trauma .similar findings were

Table-26. Relation between risk factors for progression of follow up CT brain and findings in follow up CT brain

Risk factors	Finding in FU CT brain							
	INC size (n = 30)		Same (n = 11)		Resolving (n = 19)		New finding (n = 43)	
	No.	%	No.	%	No.	%	No.	%
Coagulopathy (n = 18)	6	20.0	0	0.0	1	5.3	12	27.9
Hypotension (n = 8)	3	10.0	0	0.0	0	0.0	5	11.6
Hydrocephalus (n = 7)	3	10.0	0	0.0	4	21.1	1	2.3
Low GCS (n = 23)	10	33.3	4	36.4	2	10.5	7	16.3
Old age (n = 10)	0	0.0	2	18.2	0	0.0	8	18.6
Multiple lesions on CT (n=28)	10	33.3	2	18.2	6	31.6	10	23.3
Multiple risk factors (n = 9)	5	16.7	1	9.1	0	0.0	3	7.0
Ultra-early CT (n = 30)	12	40.0	1	9.1	1	5.3	17	39.5
NIL (n = 11)	1	3.3	3	27.3	6	31.6	2	4.7
P	^{MC}p=0.116		^{MC}p=0.115		<0.001*		0.010*	

χ^2: Chi square test; MC: Monte Carlo for Chi square test; *: Statistically significant at p ≤ 0.05

Figure-26. Relation between risk factors for progression of follow up CT brain and findings in follow up CT brain



reported by Brown et al (2007), Doddamani et al (2012) and Umerani et al. (2016).

In the present study of traumatic brain injury victims, it was observed that mean age was around 31.6 years (range 1.5-84). Similar findings were reported by Doddamni et al and Umerani et al where the mean age was 38.6 and 44 years old, which is the most active period in life (Doddmani et al., 2012; Umerani et al., 2016).

On assessing the hemodynamic stability in this study on admission 90% of them were hemodynamically stable with SBP>90 while 10% were hemodynamically unstable with SBP<90, with following up the CTs of these 10 patients show changes in their follow up CTS in the form of new changes or increase in the size of the initial lesion signifying that hemodynamic instability can be considered as a risk factor for progression of initial CT finding as mentioned by Kaups et al, 2004).

With respect to GCS on admission 53% had moderate TBI while the remaining 47% had severe TBI, compared to the study made by Brown et al 15% had moderate TBI and 33% had severe TBI while Umerani et al included 59% moderate TBI and 19 % severe TBI, the rest of the patients both studies had mild TBI which we excluded from our study (Brown et al., 2007), (Umerani et al, 2016).

On assessing the mode of trauma of the 100 patients enrolled in this study, road traffic accidents was the most common mode of trauma responsible for 73 % of TBI followed by falling from height and falling down both representing 9% of TBI, this results were similar to the study made by Doddamani et al where the most common mode of trauma was RTA 67% followed by FFH 24% as well as Umerani et al where RTA represent 70% of mode of trauma.(Doddamani et al ., 2012), (Umerani et al., 2016).

The interval between the timing of onset of trauma and the timing of the initial Ct brain was recorded in the current study, it was found to be ranging from 2 to 6 hours with mean time range 3 hours, in the study made by Doddamani et al, the mean time interval was 4 hours quite similar to our study. (Doddamni et al., 2012).

On studying the impact of the timing of initial CT on management of TBI patients, around 70% of the 21 patients who undergo surgical intervention did their initial CT brain after 2 hours of the onset of trauma while 28.5% had their initial CT brain after 4 hours. 60% Of the 40 patients who received medical treatment did their initial CT after 2 hours of the onset of trauma and 10% who had their initial CT brain after 6 hours received medical therapy after their follow up CT, In the 4 patients who had medical then surgical intervention, 3 had their CT brain after 4 hours and 1 after 6 hours.

The current study showed that performing an initial early CT brain within 2 hours interval from onset of trauma had a significance (P value =0.012) in comparison to 4 hours and 6 hours interval, this was similar to the study made by Oretal et al (2004) and Brown et al (2007).

Mixed lesions was the most common finding in the initial CT brain in the current study representing 45% of initial CT findings followed by brain contusions 19 % then SAH and SDH both of which representing 9% and brain oedema and EDH both of which representing 8% similar results were observed by Doddamani et al (2012) and Umerani et al (2016).

On assessing the relation between the initial CT brain findings and findings on follow up CT brain, it was significant in patients who showed new findings in the follow up CT brain (43 patients) (p value=0.031) shown in the patients who had mixed lesions and contusions. Also it was significant in the patients who showed increase in the size of their initial lesions (30 patients) (p value=0.001) shown in patients who had mixed lesions, SDH and EDH in their initial CT brain this is also coinciding with what is found out by Doddamani et al (2012) and Umerani et al (2016).

In the 100 patients included in our study, 44 patients did follow up CT brain routinely, 39 patients did it as result of deteriorated GCS and 17 patients did it on improvement of their GCS.

The most encountered finding was appearance of a new lesion which was encountered in 43 patients followed by increase in the size of the new lesions in 30 patients, resolving of the initial lesion was encountered in 19 patients and the follow up CT brain remains the same as the initial in 11 patients.

On assessing The relation between the indication of follow up CT brain and findings on follow up CT brain, there was no statistical significance between follow up CT done upon change in GCS and follow up CT done routinely in patients who had increase in the size of their lesions, (p=0.7), or had new findings in their lesions ,(p=0.9) , showing the importance of both of them .It was obvious that deteriorating GCS as an indication is more important than improving GCS and routine indications as regard number of patients.

There was statistical significance between follow up CT done upon change in GCS and follow up CT done on routine basis in the patients who had no changes in their lesions in their follow up CT brain,(p=0.01), that was shown in the patients who had their CT routinely .The same significance was found in patients who had resolving lesions in their follow up CT brain shown in the patients who had it upon change in their GCS (p=0.025), of note that all of those patients were showing improving GCS.

The current study showed no statistical significance between follow up CT done on routine basis and that done upon GCS change on analysis of relation of indication of follow up CT to impact on management, showing importance of both in the management of TBI.

The difference in the impact of management according to the indication of the follow up CT was obvious as the 65 patients who had change in management either medically or surgically, 60% where upon clinical deterioration and 40 % were upon routine scans. This is similar to what found by Doddamani et al (2012).

In other words, the current study showed that all of follow up CT done upon clinical deterioration affected the management. This indicate that patients with deteriorated GCS should immediately undergo follow up CT brain as this will greatly affect their management, this is coinciding to what found by Yamaki et al and Servadi et al where all of the CTs ordered upon clinical worsening led to intervention while Brown et al CT scans ordered due to clinical worsening was followed by medical or surgical intervention in only 38 % of patients. (Yamaki et al., 1990; Servadi et al., 1995; Brown et al., 2007).

60% of the follow up CT which were done routinely affect the management which is considered a high percentage compared to what mentioned by Brown et al that CT scans ordered routinely triggered intervention in only 1% of patients, The difference may be attributed to that Brown et al included mild TBI in his study while in our study we excluded them (Brown et al., 2007).

This signify that changes in the follow up CT brain can take place without GCS deterioration that may alter the management of TBI patients, this support the studies which recommend serial scanning for patients with significant head injury to allow prompt intervention to minimize secondary brain injury (Wang et al., 2006; Figg et al., 2003; Smith et al., 2007).

None of the CTs done upon improved GCS (n=17) impacted the management of these patients clarifying that patients with improving GCS should not have routine follow up CT brain as this did not impact their management.

During study for the relation between the severity of TBI, the indication of the follow up CT brain, and the impact on management.

It is clear that in moderate TBI patients, follow up CT brain made upon GCS deterioration impacted management medically or surgically more than those done routinely, this is similar to what mentioned by Wang et al, (2006).

In severe TBI patients, follow up CT brain done routinely impacted management either surgically or medically more than those made upon GCS deterioration, this is different to what mentioned by Brown et al where most of the severe TBI patients who undergo surgery were after their GCS deterioration (Brown et al., 2007).

The timing of the first follow up CT brain was recorded in the current study, most of the patients undergo their follow up CT brain at intervals of 4, 6 and 12 hours (24 %, 29%, 36%) respectively from the initial CT, mean time for initial follow up CT brain was 8 hours .this was similar to study conducted by Oretal et al but different from the mean time for follow up CT brain by

Doddamni et al (2012) was 26 hours as well as Naryan et al (2009) was 24 hours (Oretal et al., 2002; Doddamani et al., 2102; Naryan et al., 2008).

The relation between the timing of the first follow up CT brain and the impact on management of patients was showing statistical significance ($p<0.001$), which show the importance of a timely initial follow up CT in the management of TBI patients.

This statistical significance was shown mainly in surgically managed patients mainly in time interval of 4 hours also statistical significance was found in patients who undergo observation after first follow up Ct mainly after 12 hours intervals.

No statistical significance between time intervals of first follow up CT in those who were managed medically but time intervals of 6, 12 and 4 hours respectively (37%,30% and 27%) were the most to be followed by medical management .

The interval between the CTs following the first follow up CT brain was recorded, most of the follow up CTs was arranged in the time range of 12 hours (49 patients) and 6 hours intervals from the preceding CT (20 patients), while in the study by Doddamni et al (2012) and most of the follow up CTs was separated by 24 hours interval.

The relation between the interval between CTs following the first follow up CT and the management of traumatic brain injury was significant ($p<0.001$), this high statistical significance was shown in patients who were managed medically mainly in time interval of 12 hours interval, in patients who were managed surgically, it was shown mainly in time interval of 2 hours and 6 hours interval. In patients who were managed medically the surgically (n=4) in time interval of 6 hours.

This again signify the role of the timing of CT brain in the management of traumatic brain injury.

The mean number of follow up CT brain done for the patients in the current study was 3±1 CTs, in the study made by Doddamani et al, 50% had 1 follow up ,42% had 2 follow up , this may be attributed to longer intervals for CT brain to be done in that study (Doddamni et al., 2012).

On assessing the changes upon the follow up CTs done in the current study, most of the changes was seen in CT 2 (59 patients), the rest of changes was seen in CT 3 (18 patients, this is similar to what found by Doddamani et al. (2012).

The follow up CT at which alteration in management took place in most of the patients was the first follow up CT brain (CT BR 2) representing 67.5% of the medically managed patients (27% of total patients) and 52.3 of the surgically managed patients (11% of total patients), this is similar to Wang et al where 8 % of total patients were taken to surgery after second CT brain and Doddamani et al where 14 % of total patients were to taken to surgery after second CT brain (Wang et al.,2006; Doddamani et al., 2012)

The second follow up CT brain (CT BR3) also impacted the management in percentage of 27.5% of the medically managed patients (11% of total patients) and 47.6% of the surgically managed patients (10% of total patients), this is similar to Doddamni et al where 9.7% of patients undergo surgery after third CT (Doddamani et al., 2012).

The third and fourth follow up CT brain (CT BR 4 &5) did not impact the management of our 100 patients, this is similar to Doddamani et al (2012) where no change in management was dictated by follow up CTs after the third follow up.

The timing of follow up CT brain at which alteration in management take place was recorded, the majority of the follow up CT at which medical management done was arranged at 12 hours interval from the initial CT done. The majority of the follow up CT at which surgical intervention done was arranged at 4 hours interval from the initial CT done (28%). In the 4 patients with medical followed by surgical management 3 patients had their follow up CT at 12 hours.

This signify that most of the follow up CT at which management alteration took place was arranged at 4,6 ,12 hours and 24 hours , the follow up CT arranged at 36 and 48 hours impacted the management of only 6 patients who received medical treatment upon them. 60 patients undergo follow up CT brain after 48 hours, none of them show any changes except for 10 patients, but these new changes did not change the management for them so we can conclude that follow up CT done after 48 hours did not impact the management of TBI patients and should not be done. Doddamani el al observations were similar as the follow up CT which impacted management was at 12 to 24 intervals from the initial CT and those carried out after 48 hours had no impact on management as well as Umerani et al (2016) and Narayan et al (2008), (Doddamni et al., 2012),

From all of these observations ,The following study suggest a protocol to perform a follow up CT at 6, 12 and 24 intervals for patients with moderate and severe TBI as these were the most time frames where follow up CT brain that impacted management take place. After 24 hours, CT would be arranged only on basis of GCS deterioration and no CT would be arranged after 48 hours as it do not impact the management of TBI patients.

There are risk factors that can influence the timing of arranging follow up CT brain for TBI patients like coagulopathy, old age, early initial CT brain, GCS <8, multiple lesions on CT and hydrocephalus.

On relating these risk factors with progression of lesion in follow up CT, t, there was statistical significance between encountering new findings in follow up CT brain and presence of certain risk factors in TBI patients ($p=0.01$) that was shown mainly in ultra-early CT, coagulopathy and multiple lesions on CT and to a lesser extent in Old age, low GCS and hypotension.

There was no statistical significance between Increase in size of initial lesions in follow up CT brain and presence of certain risk factors in TBI patients,

however a significant proportion of patients who show increase in size of their initial lesions had certain risk factors like ultra -early CT, multiple lesions on initial CT, low GCS, coagulopathy and to a lesser extent hypotension and hydrocephalus.

Kaups et alidentified coagulopathy, hypotension, elevated ICP, and depressed GCS are risk factors for progression of CT. also Velmahos et al found older age , lower GCS and the presence of multiple lesions on CT as independent risk factors for progression of lesions on CT (Kaups et al.,2004; Velmahos et al.,2006).

Conclusion

Hemodynamic instability can be considered as a risk factor for progression of lesions in follow up CT brain as all the patients with low blood pressure in the current study show increase in size of their initial lesions or new changes in follow up CT brain.

Performing an initial early CT brain within 2 hours interval from onset of trauma has a relationship with new findings in follow up CT brain which significantly impacted management of TBI patients.

Follow up CT brain must be arranged more frequently in patients with initial CT brain showing mixed lesions and hemorrhagic contusions followed by SDH and EDH as new findings and progression of initial lesions was most encountered in these patients.

Both routine follow up CT and follow up CT upon GCS change have impact on the management of TBI, however, deteriorating GCS as an indication is more important than improving GCS and routine indications as regard number of patients .

All follow up CT done on basis of improving GCS did not show any changes so no follow up CT should be done in this situation.

All patients suffering deteriorating GCS should have a timely follow up CT as all of them show changes in their follow up CT which impacted their management.

Changes in the routine follow up CT brain can take place without GCS deterioration that may alter the management of TBI patients as 60% of CTs which were done routinely affect management.

Follow up CT brain made upon GCS deterioration impacted management medically or surgically more than those done routinely in moderate TBI while in severe TBI patients, follow up CT brain done routinely impacted management either surgically or medically more than those done upon GCS deterioration, more routine follow up CT brain should be arranged for severe traumatic brain injury .

The initial follow up CT done in time interval of 4 hours was the most to impact the management of TBI patients surgically while no statistical significance between time intervals of first follow up CT in those who were managed medically but time intervals of 6, 12 and 4 hours respectively (37%, 30% and 27%) were the most to be followed by medical management.

The intervals between the following follow up CT brain impacting the management of patients was 2 hours and 6 hours in patients who were managed surgically and 12 hours in patients who were medically managed.

Most of the changes seen in follow up CT brain was seen in CT 2 (59 patients), the rest of changes was seen in CT 3 (18 patients), CT 2 & 3 (11 patients), only 1 patient show changes in CT 4.

The follow up CT at which alteration in management took place in most of the patients was the first follow up CT brain (CT BR 2) followed by The second follow up CT brain (CT BR3).

The majority of the follow up CT at which medical management was done was arranged at 12 hours interval from the initial CT done followed by those arranged at 6 hours and at 4 hours respectively.

The majority of the follow up CT at which surgical intervention was done was those arranged at 4 hours interval from the initial CT done followed by those arranged at 12 hours and 24 hours.

Follow up CT arranged at 36 and 48 hours impacted the management of only 6 patients who received medical treatment upon them, follow up CT done after 48 hours did not impact the management of TBI patients .

The following study suggest a protocol to perform a follow up CT at 4- 6, 12 and 24 intervals for patients with moderate and severe TBI as these were the most time frames where follow up CT brain that impacted management take place.

Encountering new findings in follow up CT brain has an intimate contact with presence of certain risk factors in TBI patients like ultra-early CT, coagulopathy, multiple lesions on CT and , Old age, low GCS and hypotension.

Recommendations

- Arranging follow up CT for patients with low blood pressure is recommended as all of them show changes in their follow up CT.
- Ultra early initial CT recommend arranging earlier and more frequent follow up CT.
- Follow up CT should be done as soon as possible in all patients with deteriorating GCS.
- Follow up CT should be recommended more frequent in patients with initial CT brain showing mixed lesions and contusions as well as SDH and EDH.
- Follow up CT is not recommended in patients with improving GCS.
- Patients with severe TBI should have more frequent routine follow up CT as changes in follow up CT that impact management can take place without GCS deterioration.
- Initial Follow up CT brain is recommended to be done at 4 to 6 hours interval.

- Intervals between further follow up CT brain is recommended is to be done at 12, 24.
- Arranging follow up CT at 36 to 48 hours should on case to case basis.
- Arranging follow up CT after 48 hours is not recommended.
- Arranging more than 3 follow up CTs is not recommended except on case to case basis.
- Presence of risk factors like old age, coagulopathy, multiple lesions in initial CT and low GCS recommend arranging earlier and more frequent follow up CT.

Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

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